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Antibacterial Activity of *Psidium guajava* L. Leaf Extract in Herbal Acne Patch: Formulation and Evaluation

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Abstract
Acne vulgaris is the most prevalent chronic skin condition, often caused by *Propionibacterium acnes*. Growing concerns over antibiotic resistance and side effects of synthetic treatments have increased interest in herbal alternatives. *Psidium guajava* L. leaves possess antimicrobial and anti-inflammatory properties, making them a promising candidate for an herbal acne patch (HAP) formulation. This study aimed to optimize an HAP containing *P. guajava* leaf extract and evaluate its quality and anti-acne activity. The leaves were prepared, characterized, and extracted via maceration. The minimum inhibitory concentration (MIC) of the extract was determined. Patch bases were formulated using various concentrations of HPMC, HPMC-PVP, and HPMC-PVA that were selected for their film-forming ability, mechanical strength, elasticity, and biocompatibility. The optimal base was combined with extracts at 4%, 8%, and 12% to prepare the HAP. The quality and anti-acne activity were evaluated and statistically analyzed using ANOVA and the Bonferroni post hoc test. The optimized formula, F6 (HPMC 3.5%: PVA 1.5%), with 12% extract, met all quality criteria and exhibited anti-acne activity comparable to that of a marketed patch containing chlorhexidine. The F6 formula demonstrated a strong inhibition zone (14.22 ± 0.27 mm), indicating its potential as a natural and effective alternative for acne treatment.

Keywords: antiacne, HPMC, patch, *Propionibacterium acnes*, PVA, PVP

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Formulasi dan Evaluasi *Herbal Acne Patch* yang Mengandung Ekstrak Daun *Psidium guajava* L.

Abstrak
Acne vulgaris merupakan penyakit kulit kronis dengan prevalensi tertinggi di dunia, salah satu penyebab utamanya adalah *Propionibacterium acnes*. Kekhawatiran terhadap resistensi antibiotik dan efek samping dari anti-jerawat sintetik mendorong eksplorasi bahan herbal sebagai alternatif. Bagian daun *Psidium guajava* L. diketahui memiliki aktivitas antimikroba dan antiinflamasi, sehingga berpotensi diformulasikan menjadi herbal acne patch (HAP), sejalan dengan tren terapi anti-jerawat berbasis bahan alam. Penelitian ini bertujuan mengoptimasi formulasi HAP mengandung ekstrak daun *P. guajava* dan mengevaluasi kualitas serta aktivitasnya pada *P. acnes*. Daun disortasi, dikeringkan, dikarakterisasi, dan diekstraksi menggunakan metode maserasi. Konsentrasi hambat minimum (KHM) kemudian ditentukan. Basis patch diformulasi dengan variasi tipe dan konsentrasi polimer (HPMC, HPMC-PVP, dan HPMC-PVA) berdasarkan kemampuan membentuk film, kekuatan mekanik, elastisitas, dan biokompatibilitasnya. Basis optimal digunakan untuk membuat HAP dengan penambahan ekstrak 4%, 8%, dan 12%. Evaluasi kualitas dan aktivitas anti-jerawat dilakukan menggunakan metode difusi cakram, kemudian hasilnya dianalisis secara statistik menggunakan ANOVA dan uji Bonferroni post-hoc. Formula terbaik adalah F6 (HPMC 3,5%; PVA 1,5%) dengan 12% ekstrak yang memenuhi seluruh parameter mutu dan menunjukkan aktivitas anti-jerawat yang setara dengan patch komersial berbahan aktif klorheksidin (p=0,473), menghasilkan zona hambat 14,22 ± 0,27 mm. Hasil ini menunjukkan potensi F6 sebagai alternatif herbal untuk terapi jerawat.

Kata Kunci: anti-jerawat, HPMC, *patch*, *Propionibacterium acnes*, PVA, PVP

1. Introduction

Acne vulgaris is a prevalent skin condition affecting 9.4% of the global population across a broad demographic, making it the 8th most prevalent disease worldwide,[1] that often requires effective and gentle treatments. One of the common causes of acne is an infection with *Propionibacterium acnes*. Commonly used synthetic treatments, including antibiotics and retinoids, can lead to adverse effects such as skin dryness, irritation, and even antimicrobial resistance with long-term use. This has led researchers and consumers to explore natural, plant-based alternatives for managing acne symptoms.[2,3]

Among the acne treatments available, acne patches are one of the fastest-growing trends in anti-acne treatment, with a market value of $478.74 million in 2022, estimated to double by 2030.[4] The term 'herbal acne patch' (HAP) refers to an acne patch containing natural ingredients with antimicrobial and anti-inflammatory properties. This type of patch covers acne and provides additional benefits, including reducing swelling, redness, and the pain associated with acne.

Psidium guajava, or guava, is a plant with established therapeutic properties, including antibacterial, anti-inflammatory, and antioxidant activity. These benefits are attributed to the secondary metabolite content in guava, particularly in its leaves, such as flavonoids and tannins, which are known to exhibit these activities.[5] These properties make guava leaf extract a promising candidate for formulation as HAP. The formulation of HAP must undergo optimization, including selecting the polymer matrix as the patch base and incorporating the extract concentration. The optimization process ensures HAP complies with quality specifications and demonstrates therapeutic efficacy.

An ideal polymer for a patch base should fulfil several requirements, such as adequate stability and high compatibility with the active agent and other components used in the formulation.[6] HPMC, PVP, and PVA are among the polymers that meet the criteria, with each polymer having its own advantages and disadvantages.

By combining these polymers, it is expected to produce a stable, strong, flexible, and effective patch. Therefore, this research aims to optimize the formulation of an herbal acne patch containing *Psidium guajava* L. leaf extract and evaluate its quality and anti-acne activity against *P. acnes*. This approach aligns with the global trend toward sustainable, eco-friendly skincare products and highlights the therapeutic potential of native plant species in Indonesia.

2. Materials and Methods

2.1. Tools

Analytical balanced (Kern®), autoclave (Allamerican®), beaker glasses (Pyrex®), grinder (Miyako®), calipers, ceramic fiber muffle furnace®, condenser, crucibles, desiccator, disc paper, electric stove (Maspion®), Erlenmeyer flasks (Pyrex®), filter paper, glass cylinders (Pyrex®), inoculation needle, incubator (Memmert®), macerator, magnetic stirrer, micropipette (Microlit®), mortier, oven (B-One®), parchment papers, petri dishes, pipette, porcelain dish, rotary evaporator (IKA® RV 10 basic), spatula, spirtus, stamper, stirring rod, test tubes (Pyrex®), tube rack, tweezers, vials, watch glass, water bath (B-One®).

2.2. Materials

Guava leaves (*Psidium guajava* L.), *Propionibacterium acnes,* 70% ethanol (Emprove®), 96% ethanol (Emsure®), chloroform (Emsure®), 0.9% physiological NaCl (Widata Bhakti®), distilled water (Daya Chemical®), hydroxypropyl methylcellulose (Quadrant®), hydrochloric acid (HCl) (Merck®), nutrient agar (NA) (Himedia®), polyvinylpyrrolidone (Quadrant®), propylene glycol (Quadrant®), sodium benzoate (Emsure®), toluene (Daya Chemical®).

2.3. Methods

2.3.1. Guava Leaf Simplicia Preparation

One kg of fresh guava leaves was obtained from Margawati, Kabupaten Garut. The leaves were cleaned, sorted, and then air-dried. The dried leaves were then cut and ground into a powdered crude simplicia, then characterized.[7]

2.3.2. Guava leaf extract preparation

200 g of powdered simplicia was added to the macerator and soaked in 2 L of 96% ethanol for 3 days, with solvent replacement conducted every 24 hours. The soaked crude was stirred 2-3 times per day at room temperature and protected from light. The extract was filtered using filter paper, and the collected supernatant was evaporated using a rotary evaporator at 70 °C until a concentrated extract was obtained.

2.3.3. Determination of Minimum Inhibitory Concentration (MIC)

MIC of the extract was estimated using the solid dilution method. Each 1 mL extract (1, 2, 3, 4, 5% w/v) and 10 mL of Mueller-Hinton Agar (MHA) were mixed, added to each sterile petri dish, and left to solidify. 100 µL of

bacteria suspension was inoculated on agar surface, then incubated at 37°C for 18 hours. Bacterial growth was observed on each of the Petri dishes. The lowest concentration of extract with no *P. acnes* growth on the dish was the estimated MIC of the extract.

2.3.4. Optimization of Patch Base Formulation

The patch base was optimized by varying the type and concentration of polymers within the common range for each polymer as a film-forming agent, as reported in the literature (e.g., the Handbook of Excipients). The polymers used were HPMC, a combination of HPMC-PVP, and HPMC-PVA. The detailed composition and concentration of patch base formulations are shown in Figure 1A. The patch base was prepared using the solvent casting method. Each ingredient was dissolved in distilled water and mixed in a 10 ml-calibrated beaker. Distilled water was added until the volume reached the desired level (10 mL). The mixture was stirred using a magnetic stirrer until it was homogeneous and clear and then left to sit for 24 hours to remove the bubbles. The mixture was then poured into the mold and oven-dried at 70°C for approximately 10 hours.[8]

The quality of all patches was evaluated using organoleptic tests, weight uniformity tests, thickness tests, folding endurance tests, loss on drying tests, and moisture absorption capacity tests.

2.3.5. Herbal Acne Patch Preparation

The most optimal patch base formulation (based on quality evaluation) was used to prepare herbal acne patches. A HAP was also prepared using the solvent casting method, following the same steps as those in the previous section. The extract was added to the patch base mixture before it was poured into the mold.

2.3.6. Quality Evaluation of Patch

Organoleptic Test

An organoleptic test was conducted by observing the patch surface's color, transparency, shape, and texture.

Weight Uniformity Test

Each of the five patches from every formula was weighed using an analytical balance. The average and standard deviation (SD) of the results were calculated.

Thickness Test

Each five patch's thickness from every formula was measured using a caliper. The average and standard deviation (SD) of the results were calculated.

Folding Endurance Test

Patches from each formula were folded repeatedly until broken or split. The number of folds indicated the patch's endurance.

Loss on Drying

Patches from every formula were weighed (Initial weight), and then they were put in desiccator containing silica for 24 hours, then reweight (End weight).
LoD was calculated by:

$$LoD\ (\%) = \frac{W0 - W1}{W0} \times 100\%$$

W0 = Initial weight
W1 = End weight

Moisture Absorption Capacity

Patches from every formula, which had been put in a desiccator containing silica for 24 hours, were weighed (initial weight). The patches were then left in an open space at room temperature for 24 hours and reweighed (end weight). Moisture absorption capacity (MAC) was calculated by:

$$MAC\ (\%) = \frac{W0 - W1}{W0} \times 100\%$$

W0 = Initial weight
W1 = End weight

Elongation Breaking Test

The patch length was measured using a caliper (initial length), then stretched to the point just before it broke. The length was then remeasured (end length). The percentage of elongation breaking (EB) was calculated by:

$$EB\ (\%) = \frac{L0 - L1}{L0} \times 100\%$$

L0 = Initial length
L1 = End length

Swelling Index

A patch was weighed (initial weight), then 1 mL of distilled water was dropped onto the patch, and it was then incubated for 1, 3, 5, 8, 24, and 48 hours. The patch was reweighed. The swelling index (SI) was calculated by:

$$SI\ (\%) = \frac{W0 - W1}{W0} \times 100\%$$

W0 = Initial weight
W1 = End weight

2.3.7. Antiacne Activity Test

Approximately 1 mL of *P. acnes* suspension was inoculated into 20 mL of liquid NA medium, and then poured into Petri dishes, where it was allowed to solidify. Negative control (patch base), positive control (Oxy *patch*), and patch test samples (patches containing 4%, 8%, and 12% extract) were placed on the medium containing bacteria. The Petri dishes were incubated at 37°C for 18 hours. The diameter of the inhibition zone was measured (in mm). The results were analyzed statistically using a one-way ANOVA test, followed by a post hoc Bonferroni test. The data were considered significant if the p-value was less than 0.05.

3. Result

The characterization results of *Psidium guajava* L. leaves (Table 1.a) showed that simplicia met all specification requirements from Farmakope Herbal Indonesia, confirming its quality and suitability for extraction and formulation as HAPs. From 200 grams of simplicia, 32.18 grams of concentrated extract were obtained, yielding 16.09%. The MIC of the extract was determined by observing the lowest extract concentration at which no *P. acnes* growth was observed. At 4% and 5% (w/v) of extract, there was no bacterial growth. It was concluded that the estimated MIC of the extract was 4% (Table 1.b). The MIC result was used to determine the amount of extract required for HAP formulation.

The patch base formula was optimized by varying the concentration and the type of polymers. Initially, only HPMC was used (B1-B3), but based on quality evaluation, the strength and endurance of B1-B3 were not satisfactory (< 200 folding cycles). Thus, in six additional formulations (B4-B9), HPMC was combined with PVP or PVA to improve strength and endurance. The quality evaluation results were used to determine which patch base was the most optimal for formulation as HAP. Based on the results, two optimal patch-based formulas met all the quality specifications (B4 and B7) (Table 3.b and figure 1.a). All tested concentrations of extract (1×, 2×, and 3× MIC) were incorporated into each patch base (B4 and B7) before the molding process, resulting in six HAP formulations (F1-F6) (Table 2). The HAPs were evaluated using the organoleptic test, weight uniformity, thickness test, folding endurance test, LoD, MAC, elongation breaking test, and swelling index.

The results showed that all HAP formulations met the quality specifications required (Table 4 and figure 1.b). Thus, the selection of the most optimal herbal acne patch (HAP) formulation was determined based on its anti-acne activity, which was statistically compared with the positive and negative controls.

The diameter of the inhibition zone of all patches is shown in table 5 and figure 1(c). The anti-acne activity results were analyzed statistically for normality, homogeneity, and an ANOVA test for inter-formula significance. The normality test revealed that the p-value for all HAP formulations was greater than 0.05. ANOVA test was then conducted, resulting in p-value <0.05, which means the inhibition diameter data between formulas were significantly different, followed by Bonferroni post-hoc test, which showed that F2, F3, F5, and F6 had no significant difference compared to concentrated extract (*p*-value >0.05), and had a considerable difference compared to negative control/patch base. Meanwhile, F1 and F4 showed no significant difference compared to the negative control (p-value > 0.05), indicating that F1 and F4 did not exhibit anti-acne activity. Among all HAPs, only F6 had no significant difference (*p*-value=0.473) compared to the positive control (*OxyPatch*®) containing chlorhexidine.

4. Discussion

Most acne patches available on the market are primarily hydrocolloid-based, without antibacterial

Table 1. (a) Characterization results of *P. guajava* leaves simplicia. (b) The determination of the minimum inhibitory concentration of *P. guajava* extract against *P. acnes*

(a)

Parameter	Results (%)	Specification (%)
Moisture content	8	< 10
Loss on drying	9.01	<10
Total ash content	5.94	<8.4
Total acid-insoluble ash content	0.67	<0.8
Total water-soluble extractive content	21.75	>18.2
Total alcohol-soluble extractive content	22.53	>15

(b)

Extract Concentration (%)	Growth of P. acnes
1	+
2	+
3	+
4	-
5	-

Table 2. Herbal acne patch formulations

Ingredients	Formula (%)					
	F1	F2	F3	F4	F5	F6
Extract	4	8	12	4	8	12
HPMC	3.5	3.5	3.5	3.5	3.5	3.5
PVP	1.5	1.5	1.5	-	-	-
PVA	-	-	-	1.5	1.5	1.5
PG	10	10	10	10	10	10
Na-benzoate	0.1	0.1	0.1	0.1	0.1	0.1
Water (Add to)	100	100	100	100	100	100

properties, or they contain synthetic antibacterial agents (such as chlorhexidine), which may cause skin irritation.[9] A study on consumer needs regarding acne patches reveals that consumers have a strong preference for acne patches with antibacterial activity from natural ingredients that are safe, effective in covering acne, absorbing pus, and yet still have good physical and aesthetic qualities (such as durability, a smooth surface, and transparency).[10]

In this study, *Psidium guajava* L. leaf ethanol extract was chosen to be incorporated as an active ingredient in HAP, with the concentrations used being 1-3× of its estimated MIC. Guava leaf ethanol extract has shown strong efficacy in preventing bacteria, including *P. acnes*. This activity is attributed to flavonoid contents of the leaf, such as guaijaverine, morin-3-O-alpha-L-lyxopyranoside, and morin-3-O-alpha-L-arabinopyranoside, which exhibit various antibacterial mechanisms.[11] Flavonoids can damage the bacterial envelope and disrupt membrane integrity, leading to cell death.[12] Additionally, they can interfere with iron homeostasis, which is crucial for numerous bacterial biological processes, such as respiration and signal transduction.[13] The other mechanisms include inhibiting bacterial efflux pumps and bacterial nucleic acid synthesis.[14,15] Besides acting as an anti-bacterial agent, these compounds also demonstrate anti-inflammatory activity, which is beneficial for acne.[16]

To develop HAP, which meets the desired quality specifications, selecting an appropriate polymer is a fundamental and critical step, as the polymer contributes to forming the patch matrix, which influences the patch's flexibility, adhesive strength, protective capability, and the delivery process of active compounds.[17] It also has to ensure adequate stability and exhibit strong compatibility with both the active agent and other excipients involved.

Primarily, B1-B3 were prepared using a single polymer, HPMC. HPMC is a biodegradable and hydrophilic polymer that has excellent biocompatibility and low toxicity.[18] It can form transparent and flexible film from aqueous solution, as in the B1 formula with a concentration of 5% HPMC. B1 also demonstrated

Table 3. (a) Patch base formulation, (b) Quality evaluation of patch bases

(a)

Ingredient	Formulation								
	B1	B2	B3	B4	B5	B6	B7	B8	B9
HPMC	5	10	15	3.5	2.5	1.5	3.5	2.5	1.5
PVP	-	-	-	1.5	2.5	3.5	-	-	-
PVA	-	-	-	-	-	-	1.5	2.5	3.5
Propylene Glycol (PG)	10	10	10	10	10	10	10	10	10
Na-Benzoate	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Distilled water	add to 100	add to 100	add to 100	add to 100	add to 100	add to 100	add to 100	add to 100	add to 100

(b)

Parameters	Formulation								
	B1	B2	B3	B4	B5	B6	B7	B8	B9
Weight Uniformity (gram)	0.037 ± 0.002	0.044 ± 0.001	0.065 ± 0.002	0.029 ± 0.004	0.027 ± 0.007	0.028 ± 0.003	0.018± 0.007	0.023 ± 0.006	0.022 ± 0.005
Thickness (mm)	0.2	0.2	0.4	0.22	0.21	0.25	0.20	0.20	0.20
Folding Endurance	189*	103*	107*	>300	>300	215	>300	>300	>300
LOD (%)	4.50	6.60	7.30	8.54	10.49*	24.57*	9.82	19.17*	15.00*
MAC (%)	2.65	10.2*	7.06	8.71	25.18	15.45	2.90	3.41	3.86

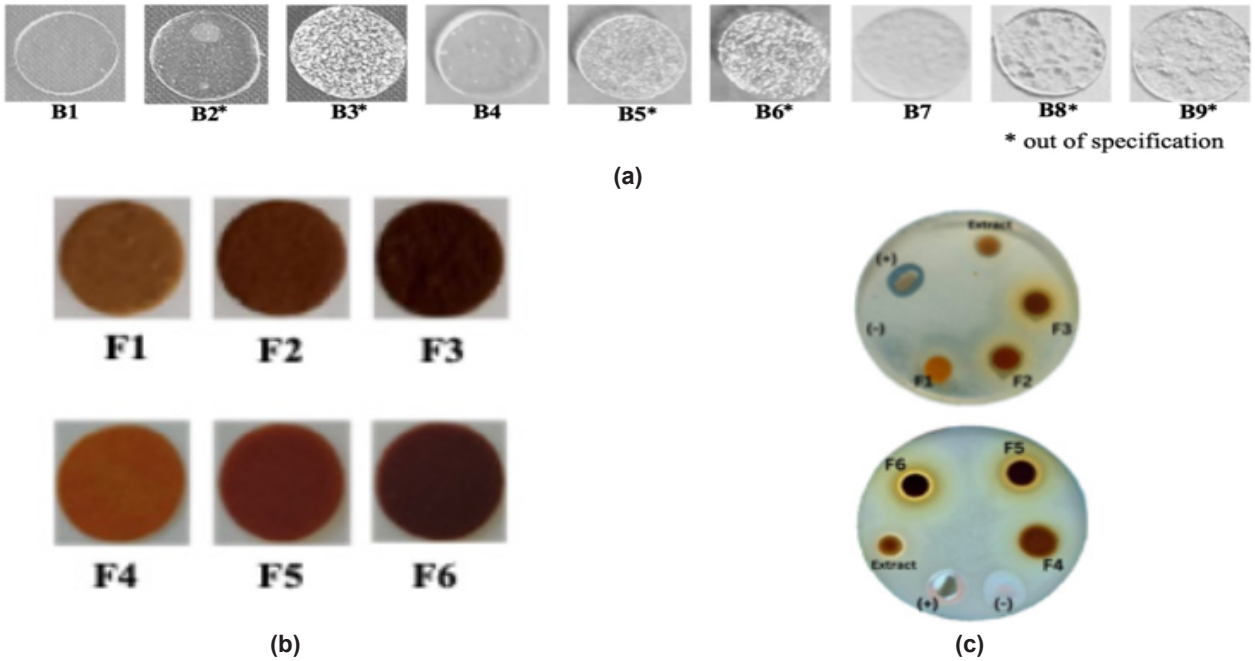

Figure 1. (a) Organoleptic evaluation of patch bases. The organoleptic requirements for a patch are a thin, transparent, and smooth surface. (b) Organoleptic evaluations of herbal acne patches. (c) Antiacne activity test of HAPs using the disc paper method

a good patch appearance, characterized by a thin, uniform weight (small SD value) and a smooth surface. Meanwhile, B2 and B3 had opaque and poor flexibility. This is because the use of higher concentrations of HPMC makes it more difficult for the HPMC to dissolve, resulting in a thicker and more opaque patch.

However, despite having a good appearance, B1 demonstrates unfavorable endurance based on the folding endurance test result, as the literature suggests that HPMC has low to moderate tensile strength.[19,20] Thus, B4-B9 were prepared using a combination of polymers, HPMC-PVP and HPMC-PVA, to improve the strength and durability of the patch. PVP is a synthetic, water-soluble polymer that has excellent wetting properties and readily forms a patch base. It exhibits better strength and adhesion compared to HPMC, while still maintaining excellent biocompatibility and non-toxicity.[20] PVP is used in the range concentration between 0,5-5 % to form a patch base (w/w). B4-B6 were optimized using different ratios of HPMC to PVP, resulting in a more transparent patch with better endurance compared to B2 and B3. However, a higher PVP concentration produced a higher moisture content and moisture absorption capacity of the patch, as indicated by the evaluation results (a higher percentage of LoD and MAC). The reason is that PVP is more hygroscopic than HPMC and PVA.[21]

The formula B7-B9 was prepared using a combination of HPMC-PVA. PVA is a copolymer of vinyl acetate and vinyl alcohol, which is biocompatible, non-toxic, and hydrophilic. It exhibits outstanding film-forming and adhesive capabilities, as well as superior tensile strength compared to HPMC. However, it has a limitation when used as a single polymer for a patch base. PVA has strong intermolecular hydrogen bonds, so its molecules bind tightly to each other, resulting in insufficient lubricant properties and making it

Table 4. Quality evaluations of herbal acne patches

Parameter	Formulation					
	F1	F2	F3	F4	F5	F6
Weight Uniformity (gram)	0.041±0.004	0.042±0.004	0.044±0.002	0.028±0.003	0.037±0.006	0.049±0.003
Thickness (mm)	0.37	0.38	0.40	0.19	0.27	0.30
Folding Endurance	>300	>300	>300	>300	>300	>300
LOD (%)	7.14	8.63	9.72	5.93	6.03	3.50
MAC (%)	9.34	9.51	13.08	14.97	11.27	6.73
Elongation (%)	26.78	15.19	15.78	39.74	17.58	14.83
Swelling Index (%)	238	202	185	370	501	212

Table 5. Inhibition zone diameters of HAP against *P. acnes*

Formulation	Inhibition zone diameters (mm)			Average ± SD
	1	2	3	
F1	0	0	0	0
F2	12.07	12.48	11.18	11.89 ± 0.66
F3	13.38	12.95	12.65	12.99 ± 0.37
F4	0	0	0	0
F5	13.56	13.44	13.05	13.35 ± 0.26
F6	14.50	14.20	13.96	14.22 ± 0.27
Extract	14.02	11.48	13.39	12.96 ± 1.32
(+)	16.44	15.54	14.71	15.56 ± 0.86
(-)	0	0	0	0

harder to fabricate as a patch base. Combining PVA with other polymers, such as HPMC, can overcome this shortcoming.[17] Based on B7-B9 evaluation, the combination of these two polymers produced a thin, transparent, and strong patch base. Among the B1-B9 formulations, B4 and B7 were the best for use as a patch base, resulting in six candidate herbal acne patch formulations (F1-F6).

Based on quality evaluations, most of the HAPs passed all the quality specifications. For weight uniformity, F1, F2, F3, and F6 demonstrated acceptable Relative Standard Deviations (<10%, ideally <5%), meaning that these formulations produced patches with uniform weights. Meanwhile, F4 and F5 resulted in high RSD (10.71% and 16.22%, respectively), indicating noticeable variability in the patch weight. For the thickness results, all the HAPs produced thin patches (<1 mm) with smooth surfaces, ranging in color from orange to brown, depending on the concentration of extract used. F1-F6 also produced strong and flexible patches based on % elongation and endurance testing results (exceeding 300 folding cycles).

The swelling index test was conducted to evaluate the retention capability, adhesion, durability, comfort, and durability of the patches. All formulations exhibited a high swelling index, indicating that the patches can absorb more exudates —a crucial property for acne patches. The high swelling index also impacts the release of active ingredients and tends to conform more closely to the skin's surface, adapting better to the customer's movement. Therefore, the decision-making process to determine the best formulation was based on the result of its antiacne activity test.

Based on the statistical analysis of the inhibition zone diameter data, F1 and F4, which contain 4% extract, showed no observable anti-acne activity. In contrast, the 4% extract, when not formulated as a patch, exhibited strong activity. This difference occurs because not all the active compounds in the patch are released due to the patch's matrix, which reduces the activity despite using the same extract concentration.

Among all formulations, only F6, containing 12% of extract, exhibited the most comparable antiacne activity to the reference patch (positive control). F6 may provide an optimal number of bioactive compounds that exhibit anti-acne activity at a level comparable to chlorhexidine. In contrast, lower concentrations in other formulations contain fewer bioactive compounds, resulting in reduced effectiveness. F6 may also have an ideal matrix composition, allowing for better diffusion and controlled release of the active compounds. Further studies, such as dose-response analyses and release kinetics, would be needed to validate these explanations.

5. Conclusion

The most optimal herbal acne patch formulation was F6, which utilized a combination of 3.5% HPMC and 1.5% PVA as the patch base. The formula 6 (F6) contained 12% of *Psidium guajava* L. leaf extract exhibiting strong antiacne activity with an inhibition zone diameter of 14.22 ± 0.27 mm. Based on statistical analysis, the activity of F6 was comparable to that of the marketed product available, suggesting its potential as a natural alternative for acne treatment. This formulation offers a promising approach to reduce reliance on synthetic antiacne and aligns with the growing demand for sustainable natural skincare.

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Conflict of Interest

The authors declare no conflicts of interest.

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